

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 523 253 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art.
158(3) EPC

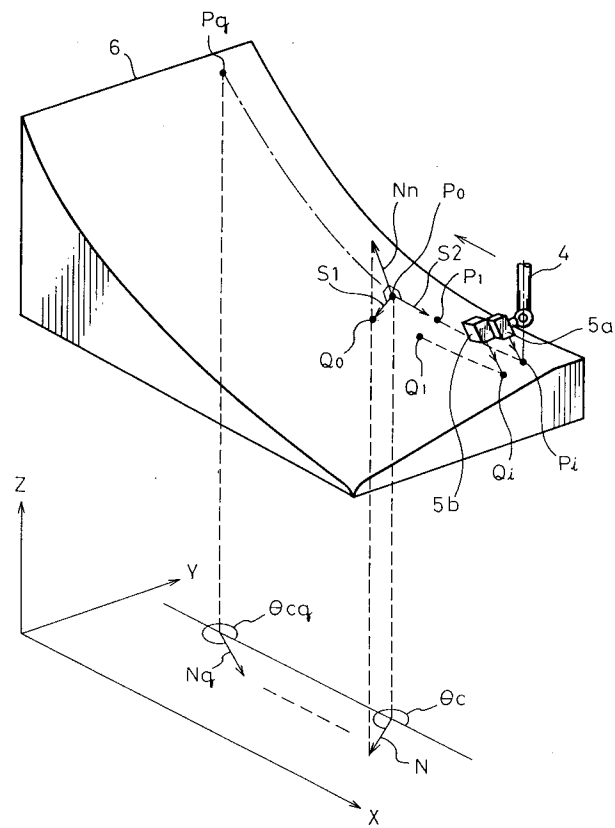
(21) Application number: **92904400.6**(51) Int. Cl.⁵: **B23Q 35/127, G01B 21/20**(22) Date of filing: **06.02.92**(86) International application number:
PCT/JP92/00122(87) International publication number:
WO 92/13677 (20.08.92 92/22)(30) Priority: **06.02.91 JP 36897/91**(43) Date of publication of application:
20.01.93 Bulletin 93/03(84) Designated Contracting States:
DE GB IT(71) Applicant: **FANUC LTD.**
3580, Shibokusa Aza-Komanba, Oshino-mura
Minamitsuru-gun, Yamanashi 401-05(JP)(72) Inventor: **MATSUURA, Hitoshi 2-202, Keio**
Yamada Mansion
412-7, Midori-cho
Hachioji-shi Tokyo 193(JP)
Inventor: **MATSUMOTO, Eiji Fanuc Dai-3**
Vira-karamatsu
3527-1, Shibokusa Oshino-mura
Minamitsuru-gun
Yamanashi 401-05(JP)(74) Representative: **Brunner, Michael John**
GILL JENNINGS & EVERY, Broadgate House,
7 Eldon Street
London EC2M 7LH(GB)(54) **DEVICE FOR CONTROLLING NON-CONTACT DIGITIZING.**

(57) A device for controlling digitization with a high accuracy which realizes the optimum attitude control of a non-contact distance measuring device on the face of a model to be copied. A non-contact distance measuring means (105) samples the coordinate values of plural points on the model face, and the sampled coordinate values are stored in a storage means (101). A point selecting means (102) selects

three points from those whose coordinates are stored to form a triangle which is best similar to an equilateral triangle. From the selected points, a vector calculating means (103) calculates the normal vectors. Using the normal vectors, the attitude of the non-contact distance measuring means (105) is controlled by an attitude controlling means (104).

EP 0 523 253 A1

Fig. 9



TECHNICAL FIELD

The present invention relates to a tracer control unit, more particularly it relates to a digitizing control unit.

BACKGROUND ART

A non-contact digitizing control unit and a non-contact tracer control unit that trace a model surface and machine a material so that a contour is identical to that of the model by using non-contact distance detectors have been developed recently. In this case, optical distance detectors are utilized as non-contact distance detectors, which are fixed at the top of a tracer head, measure the distances to the model surface and calculate digitizing data; then the digitizing control unit machines after completion of the model surface tracing, while the tracer control unit simultaneously traces and machines by a cutter associated with the tracer head. Such machinings by the non-contact digitizing control unit or the tracer control unit are expected in the development of applications in the tracing and machining fields because a soft surface model can be used because no cautionary measures are taken to avoid damaging the model.

Figure 1 is an explanatory drawing illustrating a laser beam from an optical distance detector, illuminated normal to a model surface, Figure 2 is a laser beam illuminated parallel to the model surface, and Figure 3 is an explanatory drawing illustrating scattered or reflected lights intercepted by the model.

In the non-contact digitizing control units of the prior art, there is a problem in that the accuracy of tracing and machining is reduced at the area where the slope angle of a model surface to the X-Y plane is large, because the distance to the model surface is measured from a determined direction to the model, e.g., Z-axis normal to the table surface (X-Y surface) on which the model is installed. That is, an optical measuring axis of the distance detector becomes substantially parallel to the model surface in this area, therefore the spot light on the model surface is enlarged in the form of an ellipse, reduces the resolution of the detector, and decreases the tracing accuracy. This means the position of the image cannot be determined and the accuracy of the obtained distance data will be decreased when the image on the light sensing element becomes large, because the distance to the model surface can be obtained by converting the current into the said distance; the current of which is generated because of the position of the image formed on the light sensing element of the optical distance detector.

The image on the light sensing element is the

image formation of an optical spot on the model surface by means of an image formation lens, so that the image on the light sensing element also becomes large if an optical spot has a large area.

The illuminated laser beam is normally not a beam but an optical bundle, therefore an optical spot on the model surface has a surface area, and because of that, the optical spot is a circle and is most appropriate when the model surface is normal to an illumination measure shaft as shown in Figure 1, while the optical spot is enlarged to an ellipse and the measuring accuracy is reduced when the model surface is steep in relation to the illumination measure shaft as shown in Figure 2.

Particularly, in the case of a distance detector by means of the triangulation method, the distance cannot be measured because of an interference between an optical measuring axis and the model surface, depends on the slope angle. Namely it cannot be measured because of the interference between the optical measuring axis and the model surface, and because of the interception of the reflection from an optical spot and scattered lights when the model angle becomes large as shown Figure 3.

For this reason a method that comprises using 2 detectors simultaneously executing a plurality of measurements by a tracer head, selecting 3 arbitrary points, determining the normal vector of a model surface by these 3 points, rotating the distance detector to the direction of the normal vector, and improving the measuring accuracy can be considered. Japanese Patent Application No. 1-194500 is an example of this kind of non-contact tracer control unit.

According to the apparatus described, a tracer control unit capable of high accuracy distance measurements can be provided by a method that comprises obtaining each coordinate of the each apex of a small square on the model surface from measured data previously and currently sampled when transferring along the tracing line of 2 non-contact distance detectors provided with the tracer head, determining the normal vector by using the coordinates of 3 desired apexes among them, rotating the tracer head the direction of projection (shadow) to the X-Y plane of the normal vector, directing the measuring shaft of the non-contact distance detector to be as close to normal to the model surface as possible.

However, with the above mentioned apparatus, there are cases in which 3 points are on a direct line or nearly equal to the direct line when 3 points are arbitrarily selected among a plurality of points, so that the normal vector of a model surface cannot be accurately obtained. Namely, the normal vector cannot be obtained when 3 points are on a direct line. Furthermore, as the surface curve

change rates of the surface model become large when 3 points are nearly equal to the direct line, an approximate plane of the model surface far from the real model surface is obtained. Therefore, the attitude control of the distance detector is performed based on the inaccurate normal vector, so that there remains a problem in that a reduction in the accuracy of a tracing cannot be avoided.

DISCLOSURE OF THE INVENTION

Accordingly, it is an object of the present invention to provide a non-contact digitizing control unit that can select the points to determine an accurate normal vector on the model surface.

According to the present invention to solve the above described problems, a non-contact digitizing control unit is provided that obtains tracing data by sampling coordinates of a plurality of points from a model surface by means of a non-contact distance detector; the attitude of which is controlled to select a direction most suitable to the model surface, characterized in that it comprises a memory means for storing coordinates of a plurality of sampled points, a point selecting means for selecting 3 points so as to compose a triangle most similar to a regular triangle from the 3 arbitrary points in said coordinates, a vector determining means for determining the normal vector on the model surface based on 3 points of the coordinates selected by the point selecting means, an attitude control means for directing the attitude of said non-contact distance determining means to the normal vector of the model surface based on said normal vector.

The digitizing control unit according to the present invention determines the normal vector by means of the vector determining means after selecting the 3 arbitrary points from a coordinates of a plurality of sampled points by the non-contact distance detecting means. At this time a triangle composed of 3 points is selected from the 3 points so as to compose the most similar regular triangle. The attitude of the non-contact detector is controlled to direct the measuring shaft to be as close to normal the model surface as possible based on the determined normal vector, and as a result accurate tracing data can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an explanatory drawing illustrating a laser beam from an optical distance detector illuminated normal to a model surface;

Figure 2 is an explanatory drawing illustrating the laser beam illuminated parallel to the surface;

Figure 3 is an explanatory drawing illustrating the scattered or reflected lights intercepted by

the model;

Figure 4 is a general block diagram of the non-contact digitizing control unit according to the present invention;

Figure 5 is a drawing illustrating the position relationship of a plurality of sampled points from the surface model;

Figure 6 is a flow chart indicating the procedure to determine the triangle;

Figure 7 is a block diagram of the non-contact digitizing control unit according to one of the embodiments of the present invention;

Figure 8 is a detailed drawing illustrating the tracer head according to one of the embodiments of the present invention; and

Figure 9 is a explanatory drawing of a method for determining the rotation angle of the tracer head.

BEST MODE FOR CARRYING OUT THE INVENTION

One of the embodiments of the present invention will be explained hereinafter, referring to the attached drawings.

Figure 4 is a general block diagram of the non-contact digitizing control unit according to the present invention. In a memory means 101, data of coordinates of a plurality of points (P_i , Q_i) sampled from the model surface by means of 2 detectors of non-contact distance detecting means 105 are stored as data for tracing and attitude control. A point detecting means 102 is to select 3 arbitrary points of tracing data, and in the unit according to the present invention, the 3 points are selected so as to compose a triangle to be most similar to a regular triangle.

A vector determining means 103 is for determining the normal vector on the model surface based on the coordinates of the 3 selected points. An attitude control means 104 is provided, for example, with the 2 detectors associated therewith having a 45° slope to the rotation shaft of the tracer head, and controls the attitude of a non-contact distance detector means 105 by rotating the rotating axis of the tracer head.

That is, the non-contact distance detecting means 105 is rotated around the axis by means of the attitude control means 104 in accord with the direction of a projection on the model installed plane to the determined normal vector. The measurement axis of the 2 detectors of the non-contact distance detecting means 105 is controlled to direct the attitude to be as close to normal to the model surface, as possible and accurate tracing data can be obtained. The tracing data of the model contour are stored in the memory means 101.

Figure 5 illustrates the relationship of the position of 4 sets of points sampled from the model surface by the above mentioned means 105 such as (P_0, Q_0) , (P_1, Q_1) , (P_2, Q_2) and (P_3, Q_3) . Assuming the current tracing point as (P_0, Q_0) , those points (P_1, Q_1) , (P_2, Q_2) and (P_3, Q_3) are tracing points respectively at the previous sampling time. Namely, now the tracing can be assumed to have proceeded from right to left in Figure 5, the coordinate data of 2 points (P_i, Q_i) sampled simultaneously from the model surface are stored as tracer data and attitude control data in the memory means 101. After defining the point P_i as a point is sampled by the detector (main detector) used for tracing control among 2 detectors, the above mentioned selecting means 102 selects the current measurement point P_0 as one of the apexes of a triangle. Furthermore when the remaining 2 points are selected from points $Q_0, Q_1, \dots$ and $P_1, P_2, \dots$, one point is determined as a sampling point P_1 that is an immediately preceding sampled point of the main detector, and the other point is selected among the 3 measurement points Q_0, Q_1 and Q_2 by the other detector by means of the determining algorithm described hereinafter.

Figure 6 is a flow chart indicating the procedure to determine the other point among the measurement points $Q_0, Q_1, \dots$ as an apex of the triangle composing the most similar regular triangle when the line segment from P_0 to P_1 , which are measurement points by the main detector, is selected as a side of a triangle. In the drawing, the numbers following the reference SP denotes the stepping number.

(SP11) The original value (i) of the other point and the point number (n), as an objective point, as well as the measurement points P_0, P_1 are determined from the memory means 101. These values of (i) and (n) are determined as a trade off between the time required for calculation and tracer control accuracy.

That is, since the greater the increase in the number of objective points, the greater the increase in the number of comparisons, and therefore more appropriate points can be selected, and although accuracy increases, greater time consumption is required because of the necessity of a greater number of calculations for comparison. On the other hand, when the number of object points is decreased, the time for calculation is reduced but accuracy also decreases.

It goes without saying that it is necessary to determine the normal vector so as to be in time for the sampling speed to the attitude control means 104. In the example of Figure 5, the original value (i) is 0 and the objective point number (n) is 3.

(SP12) First read the data of P_0, P_1 and Q_i of each measurement point, then calculate the sum

(SUM) of 3 sides of each triangle formed from the above 3 points, and calculate the maximum length (MAX) of the above 3 sides. When Q_0 is selected in Figure 5,

$$\text{SUM} = A_0 + B_0 + C_0 \text{ and } \text{MAX} = C_0.$$

(SP13) Calculate the sum of 3 sides of a triangle, and calculate the ratio between the sum of 3 sides of a triangle and the maximum length of 3 sides of the triangle, and memorize the data of R_i (= SUM/MAX).

(SP14) Calculate (i) = (i) + 1, and set the data (i) + 1 as the new data of (i).

(SP15) Compare (i) with (n), if (i) is not more than (n), return to step 12 and calculate the ratio of R_i repeatedly until (i) is more than (n).

(SP16) Finally determine the third point Q_i from the maximum value of a plurality of the calculated ratio data R_i . In this way, 3 points can be determined so as to obtain the maximum ratio (SUM/MAX) between the sum of the length of the 3 sides of triangles and the length of the maximum side of the 3 sides of the triangle.

Figure 7 is a block diagram of the non-contact digitizing control unit and the peripheral equipment according to one of the embodiments of the present invention. In the drawing, a processor 11 reads a system program stored in a ROM12 via a bus 10, and controls the general operations of a non-contact digitizing control unit 1 following the system program. RAM 13 is a data storage for storing the measured data from the distance detector that will be described hereinafter and the other temporary data. Non-volatile memory 14, not shown in the drawing is a battery back-up, stores the various parameters such as trace directions, trace speeds and so on, which are input from an operational panel 2 via an interface 15.

A tracer head 4 of a copy shaping machine 3 is provided with a distance detector 5a and a distance detector 5b. In a distance detector 5a and a distance detector 5b, semiconductor lasers or optical reflection type distance detectors with a photo-diode as a light source are used to measure the distances L_p and L_q , respectively, to the model 6 without contacting the model surface. These distances L_p and L_q are converted to a digital data value by an A/D converter 16a and 16b in the non-contact digitizing control unit 1, and are sequentially read by a processor 11.

The processor 11 calculates the transferred distance of each axis based on the distances L_p and L_q and the signals of the current position registers 19x, 19y and 19z described later, generate the velocity signals of each shaft such as V_x, V_y and V_z based on the transferred distance, commanded tracer direction signals and the command-

ed tracer velocity signals by known conventional arts. These velocity signals are converted into analog signals by each of the D/A converters such as 17x, 17y and 17z, and input to each of the servo-controllers 18x, 18y and 18z. The servo-controllers 18x and 18y drive servo-motors 32x and 32y in the copy shaping machine 3 based on the velocity signals, thereby a table 31 is transferred in an x-axis direction and y-axis direction that is normal to the page and transferred back. And also the servo-controller 18z drives the servo-motor 32z and the tracer head 4 and the tool 34 are transferred in a z axis direction.

The servo motors 32x, 32y and 32z are provided with pulse encoders 33x, 33y and 33z to periodically generate detecting pulses FPx, FPy and FPz, respectively, every motor rotation. The current position registers 19x, 19y and 19z in the non-contact digitizing control unit 1 count up and down the detecting pulses FPx, FPy and FPz in the direction of the rotation, respectively, and calculate the current position data of Xa, Ya and Za and input the data to the processor 11.

On the other hand, the processor 11 periodically samples the data of the distances Lp and Lq measured by the distance detectors 5a and 5b with the determined sampling time and controls each of the above described axis, then calculates the normal vector to the surface of the model 6 from the selected triangle by the procedure previously described using the sampled data, and generates the rotation signal SC corresponding to the direction of the projection of the normal vector on the X-Y plane. After the rotation signal SC is converted from digital data to analog data by the D/A converter 17c, the signal is input to the servo-controller 18c and drives the C-axis of the servo-motor 32c based on the signal.

This controls the distance to the model 6 kept constant as described hereinafter and rotates the tracer head 4 to the commanded angle, at the same time the table 31 is transferred to the commanded trace direction with the trace speed, and a workpiece 35 may be machined with the same contour as the model 6 by a tool 34; the z-axis of which is controlled in the same way as the tracer head 4.

Figure 8 is a detailed drawing illustrating the tracer head 4 according to one of the embodiments of the present invention. In Figure 8, the tracer head 4 is provided with a distance detector 5a with the slope angle ϕ to the z-axis, and rotates around the C-axis with the determined radius in accordance with the rotation signal SC with the command angle θ_c . And also the distance detector 5b is laid and mounted outside of the associated distance detector 5a, and controls the rotation with the command angle θ_c along with the distance detector

5a.

As previously described, due to the fact that the measured values of the distance detector 5a is feedback to the tracer control unit, the distance Lp from the detector 5a to the measurement point Pi on the model 6 is kept constant. Furthermore the distance Lp is set as the distance to the cross point between the measured axis and the z-axis and although the tracer head is rotated around the C-axis, the measurement point Pi does not move, and therefore the distance L between the tracer head 4 and model 6 is also kept constant.

The distance detector 5b measures the distance Lq to the measurement point Qi on the model 6 and inputs the data to the tracer control unit.

Next, the method for calculating the rotation angle of the tracer head 4 will be explained referring to Figure 9. In Figure 9, the measured data of the distance detectors 5a and 5b are periodically sampled with the determined interval while tracing the model 6 with the tracer head 4 and transferring relatively to the X-axis direction at the determined tracing speed. These measured data and the current position data output from the current position register are stored in the memory means 101; and the point Pi and Qi of the coordinates on the model 6 are calculated based on the stored data.

Then, from the 3 points composing the most similar triangle selected by the point selecting means 102, for example, from the coordinates (X₀, Y₀, Z₀) of the measurement point P₀ and the coordinates (X₁, Y₁, Z₁) of the measurement point Q₀, the surface vector S1 (X₁-X₀, Y₁-Y₀, Z₁-Z₀) is calculated. And also from the coordinates (X₀, Y₀, Z₀) of the measurement point P₀ and the coordinates (X₂, Y₂, Z₂) of the measurement point P₁, the surface vector S2 (X₂-X₀, Y₂-Y₀, Z₂-Z₀) is calculated.

Then, by the following formula;

$$N_n = S_1 \times S_2$$

(where N_n, S1 and S2 represent vector)

The normal vector N_n at the point P_n may be calculated as a result of the vector product of the surface vector S1 and S2.

And the angle θ_c to the X-axis of the projection N of the normal vector N_n shadowed to an X-Y plane can be given the following formula;

$$\theta_c = \tan^{-1}(J_n/I_n)$$

where

I_n: X element of vector N,

J_n: Y element of vector N

are determined, then output the angle θ_c as a command value for the C axis.

This angle changes corresponding to the slope angle of the model 6, for example, the point Pq becomes θ_{cq} .

Accordingly, since the tracer head 4 is controlled to direct the measurement axis of the distance detector as close to normal to the surface of the model 6 as possible even if the change rate of the curved surface is large, 3 points composing the most similar regular triangle can be selected and a high accuracy measurement of the distance can be obtained.

In the above described explanation, the tracer control unit has been explained, but the digitizing control unit can also obtain the same result.

And as a distance detector the optical triangulation type, eddy current type, ultrasonic type or others can be used instead of the optical reflection type.

It goes without saying that other modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the invention.

As above explained, according to the present invention the accurate normal vector can be calculated even if the change ratio of the curve surface of the model is large, because the 3 points composing a triangle that is most similar to the regular triangle are selected when determining the normal vector by selecting 3 arbitrary points from the coordinates of a plurality of sampled points by a non-contact detector.

This is, since a high accuracy distance measurement can be obtained by always directing the measurement axis as close to normal to the model surface as possible so that the tracing accuracy of the digitizing control unit can be easily improved.

INDUSTRIAL APPLICABILITY

This invention is utilized for a non-contact digitizing control unit or a non-contact tracer control unit.

Furthermore this invention can also be utilized as a product contour checker during the process of manufacturing to discriminate bad products for quality control.

Claims

1. Non-contact digitizing control unit obtaining tracing data by sampling coordinates of a plurality of points (P_i , Q_i) from a model surface by means of a non-contact distance detecting means (105) of which attitude is controlled and directed to the most appropriate direction to the model surface, characterized in that it comprises,
 - a memory means (101) for memorizing

coordinates of the sampled plurality of points,

a point selecting means (102) for selecting 3 points to compose a triangle most similar to a regular triangle from triangles composed of 3 arbitrary points of said coordinates,

a vector determining means (103) for determining a normal vector on the model surface based on said coordinates of 3 points selected by said point selecting means (102), and

an attitude control means (104) for controlling attitudes of the non-contact distance determining means (105) so as to direct the model to normal based on said normal vector.

2. Non-contact digitizing control unit as claimed in claim 1, wherein said point selecting means (102) selects 3 points so as to maximize the ratio (SUM/MAX); the ratio that is the sum (SUM) of each side of each of the triangles divided by the maximum length (MAX) of the 3 sides of the triangle.
3. Non-contact digitizing control unit as claimed in claim 2, wherein said point selecting means (102) selects a current measurement point of said non-contact distance detector as an apex of a triangle.
4. Non-contact digitizing control unit as claimed in claim 3, wherein said point selecting means (102) allows the number of the measurement points (Q_i) to be set at an arbitrary number.
5. Non-contact digitizing control unit as claimed in any one of the claims 2 to 4, wherein a plurality of non-contact detectors in said non-contact distance determining means (105) are respectively mounted on a tracer head with a determined slope angle to a determined direct axis, and obtains tracing data by sampling coordinates of a plurality of points from said model surface simultaneously by controlling the position and the attitude of the tracer head to rotate around said direct axis.
6. Non-contact digitizing control unit as claimed in claim 5, wherein said attitude control means (104) controls the point P_i at the sampling points (P_i , Q_i) fixed during attitude control.
7. Non-contact digitizing control unit as claimed in claim 5, wherein said non-contact distance determining means (105) comprises photo reflecting type detectors.
8. Non-contact digitizing control unit as claimed in claim 5, wherein said non-contact distance

determining means (105) comprises photo detectors other than said photo reflecting type detectors.

9. Non-contact digitizing control unit as claimed in claim 5, wherein said non-contact distance determining means (105) comprises eddy current type or the ultrasonic type detectors.

10

15

20

25

30

35

40

45

50

55

Fig. 1

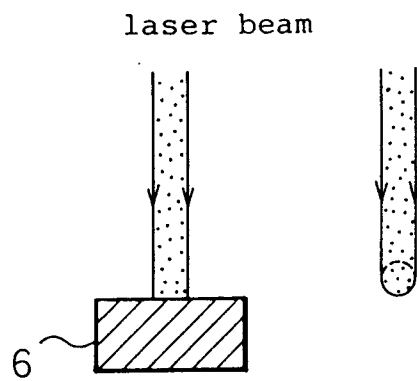


Fig. 2

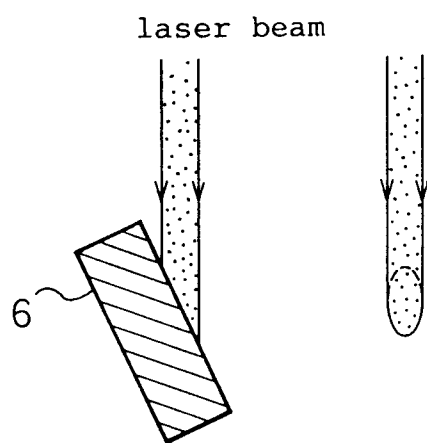


Fig. 3

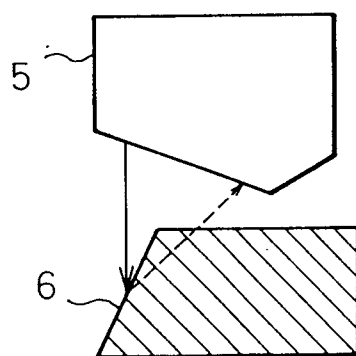


Fig. 4

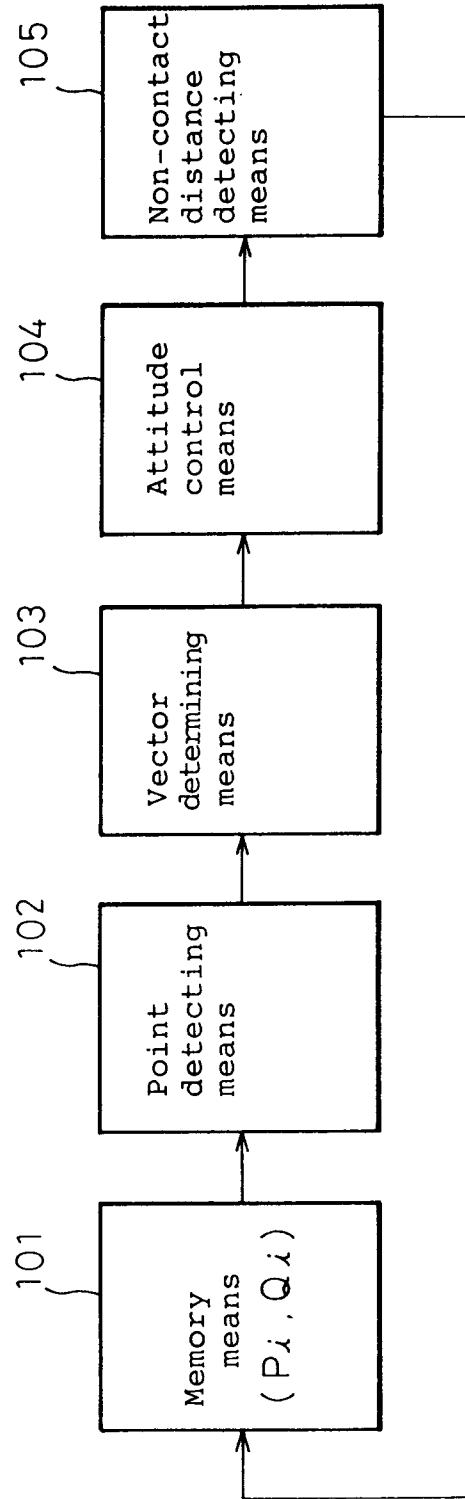


Fig. 5

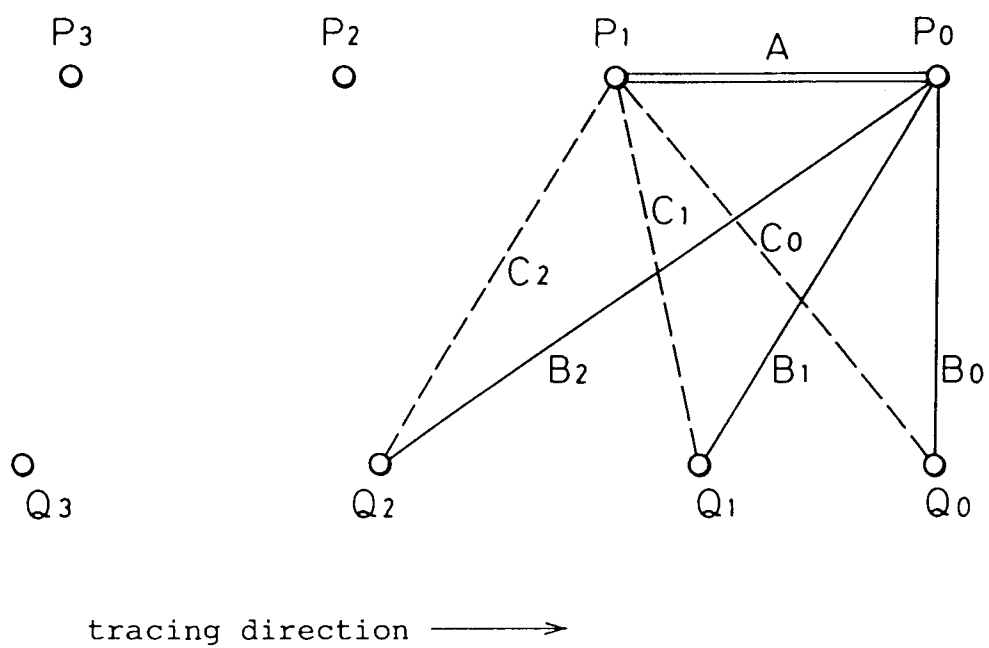


Fig. 6

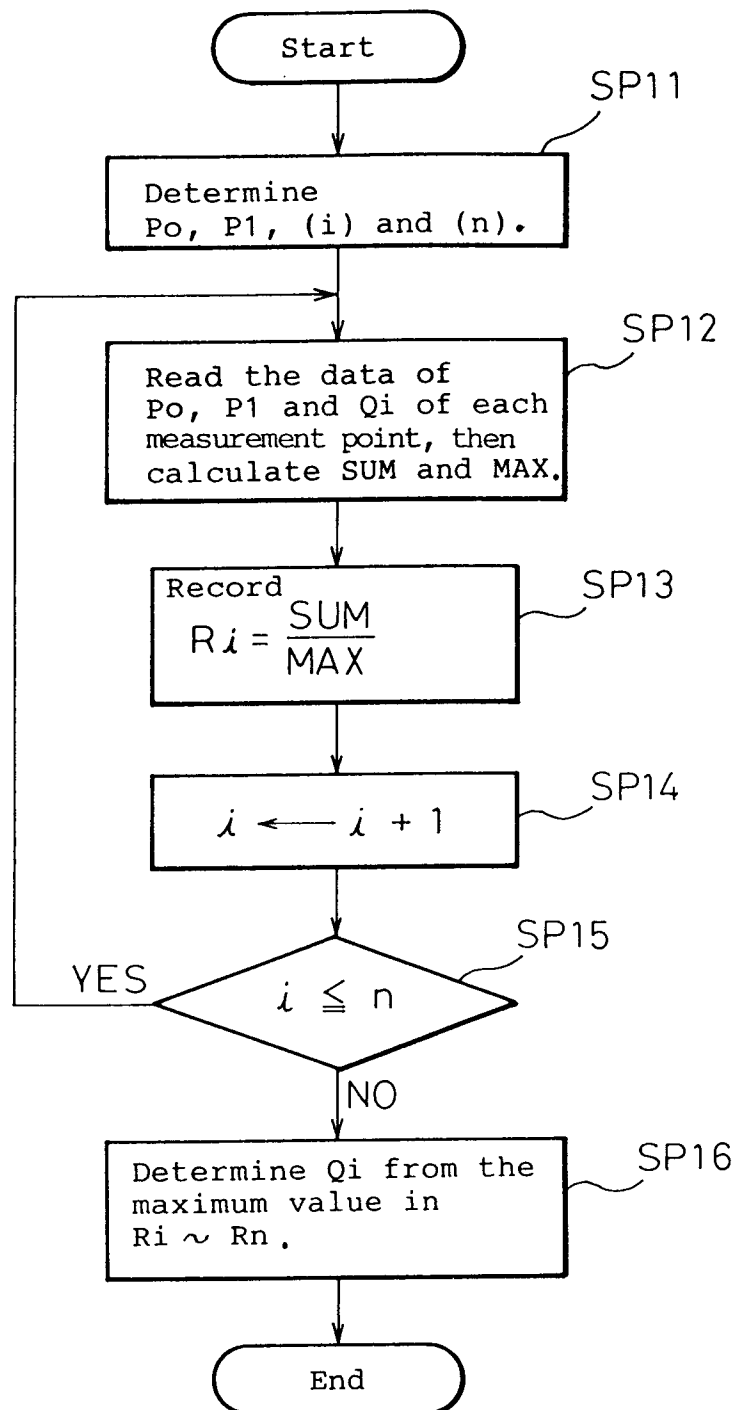


Fig. 7

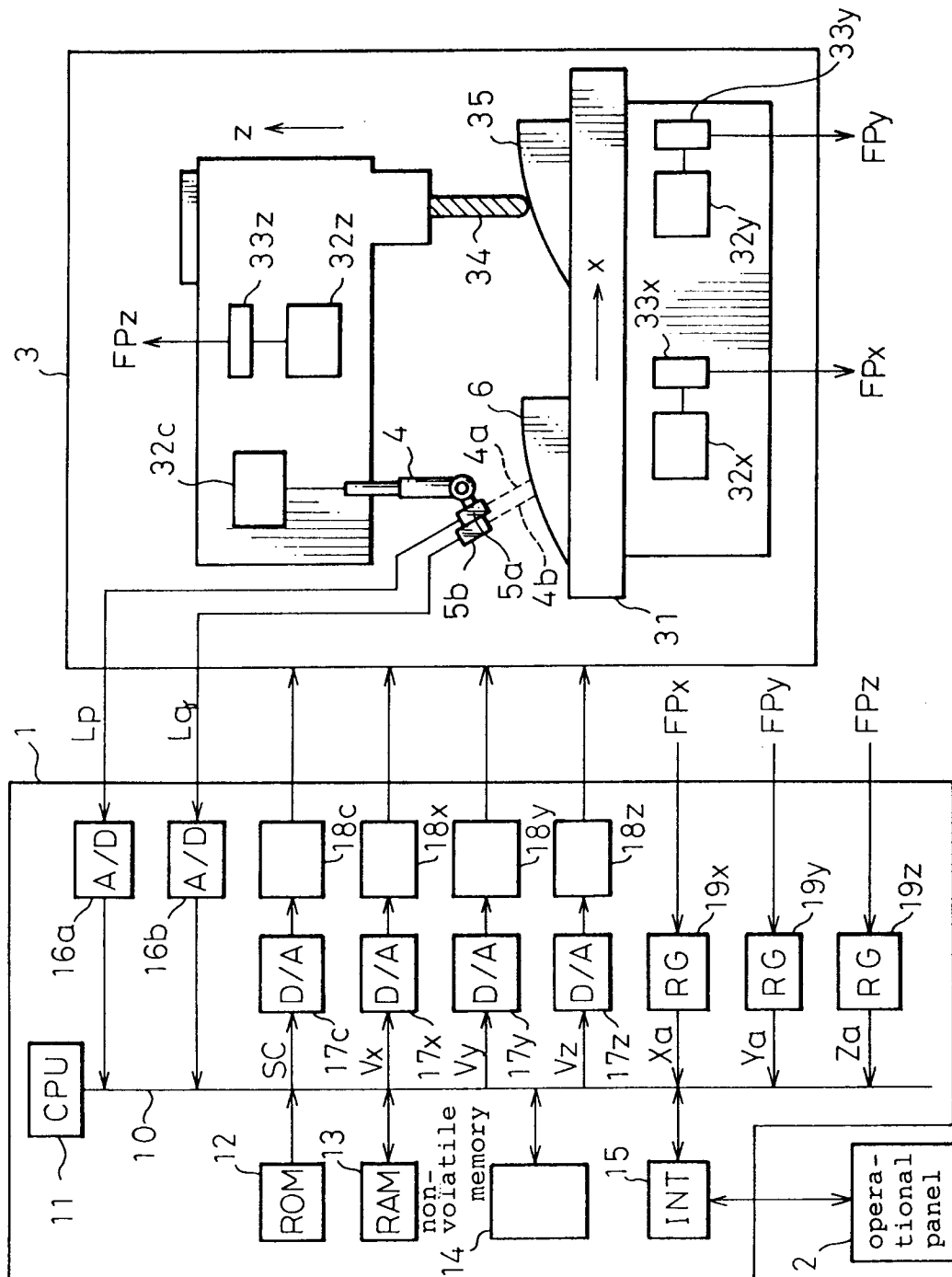


Fig. 8

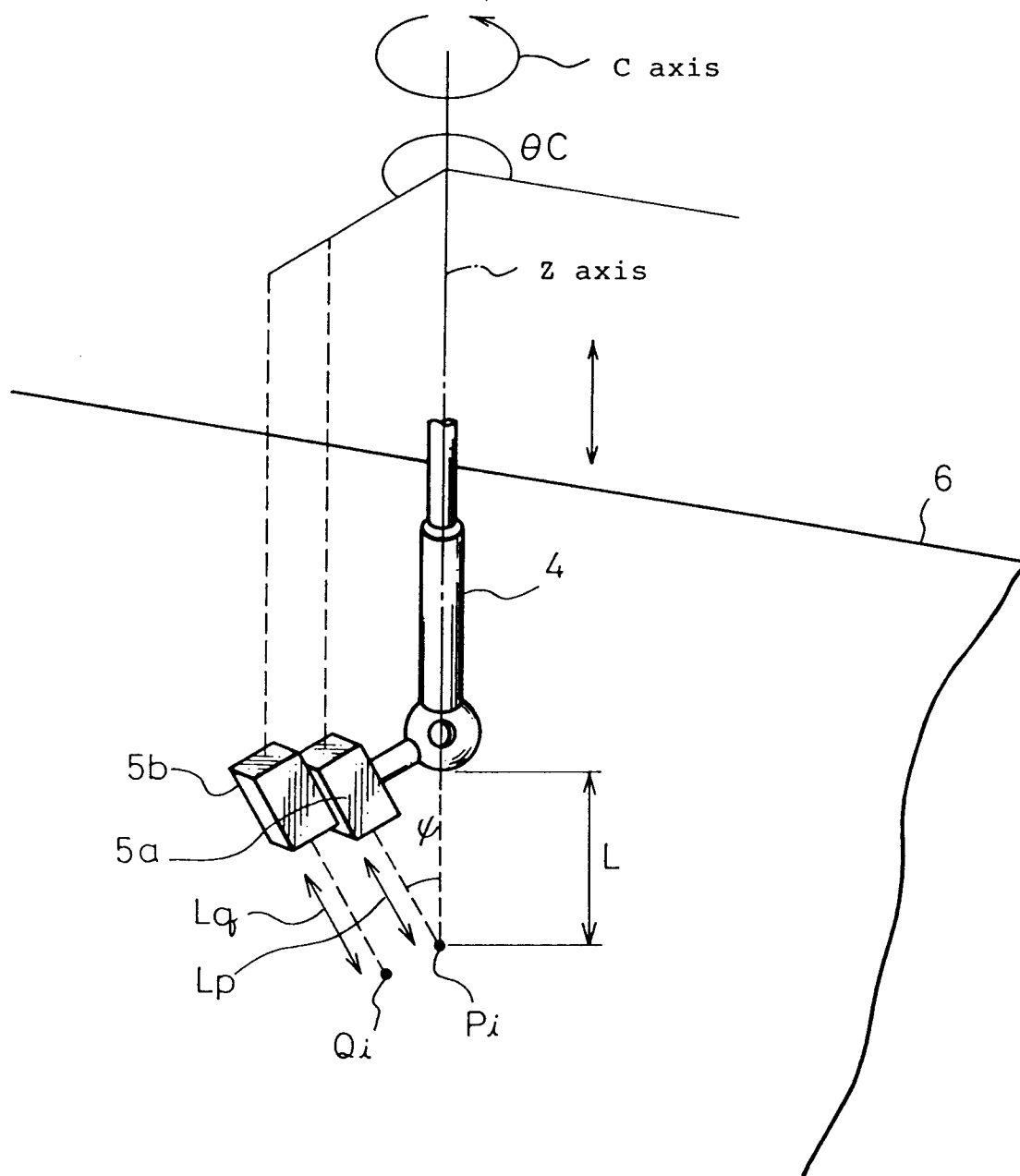
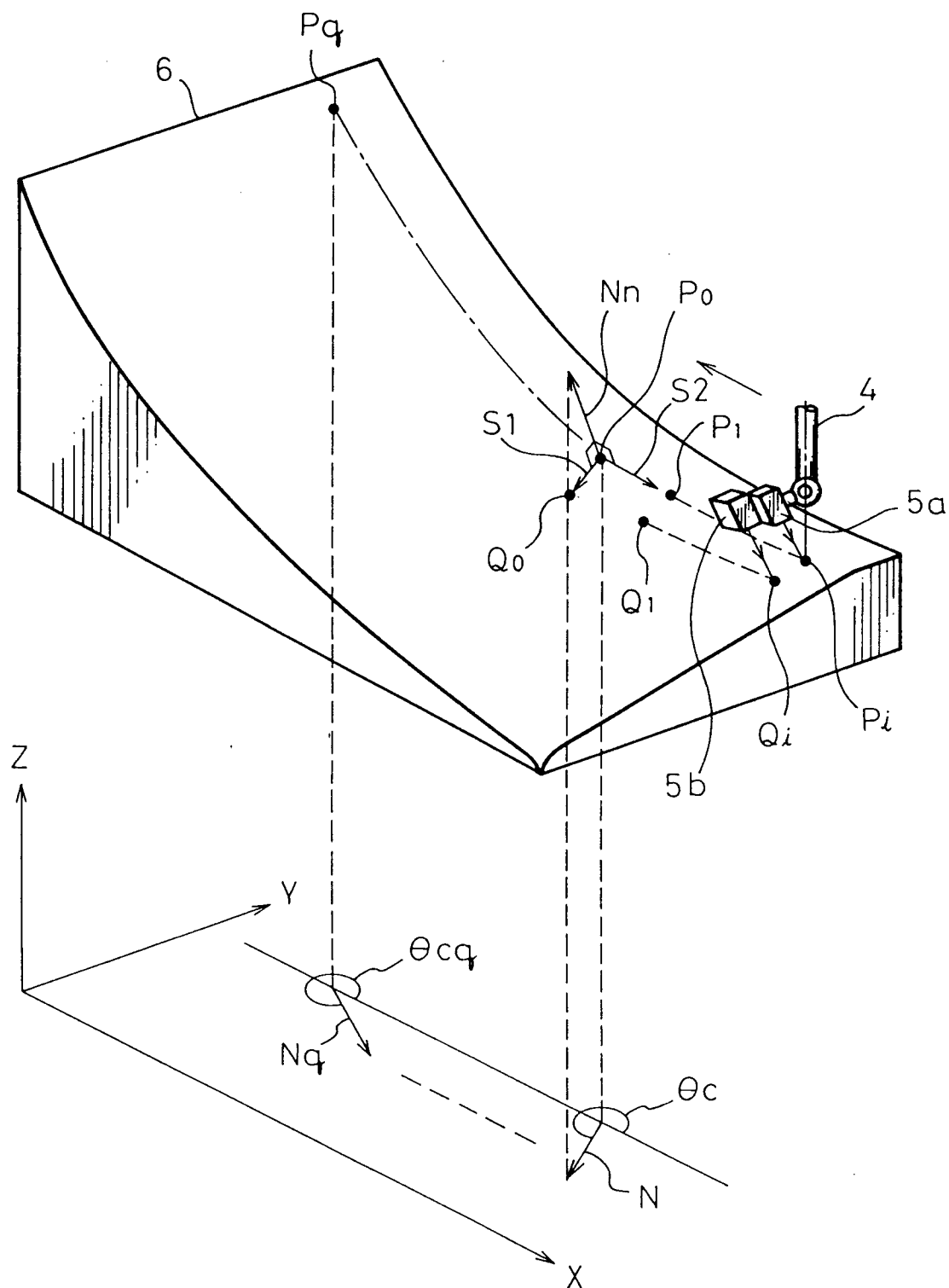


Fig. 9



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/00122

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl ⁵ B23Q35/127, G01B21/20		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC	B23Q35/127-13, 35/38, 35/40, G01B7/28, 11/24, 21/20	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
E	WO, A1, 92/04157 (Fanuc Ltd.), March 19, 1992 (19. 03. 92), & JP, A, 4-115854	1-9
E	WO, A1, 92/01534 (Fanuc Ltd.), February 6, 1992 (06. 02. 92), & JP, A, 4-82658	1-9
P	WO, A1, 91/08861 (Fanuc Ltd.), June 27, 1991 (27. 06. 91), & JP, A, 3-190652	1-8
P	JP, A, 3-121754 (Fanuc Ltd.), May 23, 1991 (23. 05. 91), Claim	1-9
P	WO, A1, 91/01849 (Fanuc Ltd.), February 21, 1991 (21. 02. 91), & JP, A, 3-60956	1-9
A	WO, A1, 90/14924 (Fanuc Ltd.), December 13, 1990 (13. 12. 90), & JP, A, 3-3760	1-9
* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
April 28, 1992 (28. 04. 92)		May 19, 1992 (19. 05. 92)
International Searching Authority		Signature of Authorized Officer
Japanese Patent Office		

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	JP, A, 1-188254 (Fanuc Ltd.), July 27, 1989 (27. 07. 89), Claim	1-9
A	JP, A, 1-109058 (Fanuc Ltd.), April 26, 1989 (26. 04. 89), Claim	1-8
A	JP, A, 64-64753 (Fanuc Ltd.), March 10, 1989 (10. 03. 89), Claim	1-8
A	JP, A, 61-274852 (Kogyo Gijutsuin-cho), December 5, 1986 (05. 12. 86),	1-8

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ²

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest
- ☐ No protest accompanied the payment of additional search fees

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Line 11, lower left column, page 2 to
line 8, lower left column, page 4
(Family: none)

V. ☒ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ²

This international Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims.
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.